

Aerospace Technology

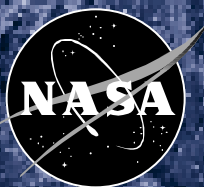
# INNOVATION

## Technologies Emerge From Mars

**Invisible, Tamper-Resistant  
Bar Codes**

**General Aviation Group  
Reports Progress**

**Aircraft May Operate  
Like Cars**



# INNOVATION

Aerospace Technology

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## Editor in Chief

Janelle Turner  
innovation@hq.nasa.gov

## Managing Editor

Karen Kafton (NTTC)

## Research

Leigh Anne Valdes (NTTC)

## On-Line Editor

Jonathan Root

## Art Direction/Production

Kelly Rindfusz  
Lillian Gipson  
Jonathan Friedman

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John Bluck  
Fred Brown  
Keith Henry  
Ann Hutchison  
Bob Lessels  
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Donald Nolan  
Robert Norwood  
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Artist's conception of the Mars Pathfinder Sojourner rover and the Carl Sagan Memorial Station lander on Mars.

**On-Line Edition:** Go to <http://nctn.hq.nasa.gov> on the World Wide Web for current and past issues.

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## COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
9/97	STS-86 (launched)** Shuttle/Mir-07	Commercial Generic Bioprocessing Apparatus Liquid Phase Sintering (samples going to Mir) Commercial Protein Crystal Growth ("sortie" mode)	BioServe Space Technologies Consortium for Materials Development in Space Center for Macromolecular Crystallography
1/98	STS-89** Shuttle/Mir-08	ASTROCULTURE™ X-ray Detector Test	Wisconsin Center for Space Automation and Robotics Center for Macromolecular Crystallography
8/98	STS-93 AXAF	AEROGEL (under consideration for assignment)	Marshall Space Flight Center
10/98	STS-95 BioTechHab (SPACEHAB short module)	To be defined; to include as many as 12 commercial development payloads covering several areas of research, in addition to other payloads	Planned payloads represent six or more of the Commercial Space Centers

Key STS—Space Transportation System, AXAF—Advanced X-ray Astrophysics Facility

\*As of October 3, 1997

# WELCOME TO INNOVATION

## Mars Pathfinder—Part of NASA's Discovery Program

**T**HE DISCOVERY PROGRAM INCLUDES A NEW generation of low-cost spacecraft designed to explore the solar system. It is one of the first missions in a new decade-long NASA program of robotic exploration to expand knowledge of the solar system while developing a number of mission technologies with promising commercial applications. The Mars Pathfinder was launched in December 1996 aboard a Delta rocket and landed almost perfectly on Mars on July 4, 1997. The Pathfinder lander and rover have continued to collect a wealth of information about the Martian environment. The Mars rover, called Sojourner, is a robust robotic vehicle capable of semi-autonomous operation on the Mars surface.

This issue of *Innovation* focuses on Pathfinder successes and on some of the new technology that was developed for the Mars lander, named the Carl Sagan Memorial Station, and the rover Sojourner. The name Sojourner was chosen for the rover after a year-long, worldwide competition in which students up to 18 years old were invited to select and submit an essay about historical accomplishments of heroic women. The students were asked to address in their essays how a planetary rover named for their heroine would translate the accomplishments to the Martian environment.

Initiated in March 1994 by the Planetary Society of Pasadena, California, in cooperation with NASA's Jet Propulsion Laboratory (JPL), the contest began with an announcement in the January 1995 issue of the National Science Teachers Association's magazine *Science and Children*, which is circulated to 20,000 teachers around schools across the nation. Vallery Ambrose, now 15, of Bridgeport, Connecticut, submitted the winning essay about Sojourner Truth, an African-American reformist who lived during the Civil War era. An abolitionist and champion of women's rights, Sojourner Truth, whose legal name was Isabella Van Wagener, made it her mission to "travel up and down the land," advocating the rights of all people to be free and the rights of women to participate fully in society. The name Sojourner was selected because it means "traveler"—in this case on the planet Mars.

To use the Pathfinder technology in commercial products, novel partnerships between industry and NASA have created unique opportunities for the JPL Commercial Technology program to link with the pri-

vate sector and entrepreneurs. The outcome desired is new products and services to contribute to the U.S. economy and public quality of life.

The Pathfinder was also a challenging project of national importance in which small and small disadvantaged businesses played high-tech roles by providing necessary off-the-shelf commodities, support services and technical personnel. These businesses were responsible for major research and development innovations in space products, hardware and software, which allowed the craft to operate in unknown extraterrestrial environments where human repair operations are impossible.

JPL's Mars Pathfinder owes a major part of its success to an innovative melding of highly reliable, commercial, off-the-shelf components and new cutting-edge NASA technologies. The Pathfinder has emerged as the quintessential model for NASA's faster, better, cheaper paradigm. Built in less than two years, it returned all the data for its one-month nominal mission in its first two and a half weeks on Mars. As of this publication, it continues to return valuable information on the Mars environment as well as data on the innovative mission technology.

While Pathfinder embraced the basic Discovery program charter that encourages use of available hardware, it also tested a number of novel systems, components and software, some showing great commercial promise. The same may be said for the Mars Exploration program as a whole, which plans a decade of inexpensive missions. This issue of *Innovation* features emerging technologies derived from the Mars mission. This Mars Pathfinder mission is the first of its kind, but not the last. We expect many new technologies to be developed for the future missions and that many of them will quickly find their way into other nonaerospace uses. We will keep you informed about them and how they might improve our lives through future issues of *Innovation*. ✨



Vallery Ambrose visits the White House and meets with Vice President Gore. Ms. Ambrose named the rover after Sojourner Truth.

# TECHNOLOGY TRANSFER

## Technologies Emerge From Mars

**T**HE MARS PATHFINDER IS ONE OF THE FIRST missions in a new, decade-long NASA program of robotic exploration. The purpose of the program is to expand scientists' knowledge of Mars while showing a number of technologies with promising commercial applications, including a partnership with Mattel Inc. The Mars Pathfinder has renewed public interest in the space program.

Some of the more interesting emerging technologies from the Mars Pathfinder and the future Mars '98 mission are the rocker-bogie suspension, silica aerogel insulation, DARTS (Dynamics Algorithms for Real-Time Simulation) software, the piezoelectric ultrasonic motor, the surface acoustic wave microhygrometer and a newly developed, lightweight carbon-fiber composite. Each of these technologies is in a different stage of development toward becoming licensable—meaning some have not been patented, some are in the process of being patented, and others are far from being patented (requiring technologies to be patented before they can be licensed). One particular commercial spinoff that has been tested by tens of thousands of children (and adults), the Sojourner rover toy, has provided education and restored public excitement about the space program.

### Toy Version of Sojourner

The Mattel Hot Wheels JPL Sojourner Mars Rover Action Pack set, a toy version of Sojourner, not only aroused interest in the space program but in other technologies as well. A novel partnership between Mattel Inc. and JPL created both a burst of licensing activity and a unique opportunity for JPL's Commercial Technology program to link with the private sector and entrepreneurs. This partnership also attracted media attention, providing a platform to focus on the direct benefits to the public from technology developed for space missions.

"We've signed 37 new licenses related to Pathfinder," states Dr. James Rooney, manager of JPL's Technology Affiliates program, including quick-turnaround consumer items such as T-shirts and hats.

The partnership evolved into a three-part toy of Sojourner, the Pathfinder spacecraft and a lander. Many of the Pathfinder rover's unique attributes



*It rocks, it rolls, it boogies—the Mattel Hot Wheels toy. JPL licensed the Sojourner rover to Mattel Inc., which manufactured the highly successful Hot Wheels JPL Sojourner Mars Rover Action Pack set, recreating such details as the rover's unusual "rocker-bogie" locomotion system. (Sojourner™, Mars Rover™ and Spacecraft Design and Images are copyright © 1996–97, Jet Propulsion Laboratory/California Institute of Technology. All rights reserved. Further reproduction prohibited.)*

are included, such as the rocker-bogie's six-wheel suspension, which has other, more meaningful commercial application possibilities.

### Rocker-Bogie Suspension

The unique rocker-bogie suspension that gives Sojourner its peculiar, insect-like look offers great stability and an enhanced ability to negotiate large rocks nearly as high as the rover itself. The JPL-patented suspension joins the three wheels on each side with only two swinging joints, and it connects the whole three-wheeled bogie to the chassis at a single point. The structure has no springs, and the freely rotating joints flex to conform to ground contours and climb obstacles. The rover combines independent drive and individual steering (Ackerman steering) for each wheel.

Perhaps the most entertaining commercialization for the stable and agile suspension system was



the Mattel toy. The more practical and useful applications for rocker-bogie technology include off-road, all-terrain vehicles for recreation, research and forestry; military scout vehicles; highly mobile handicapped assistance vehicles; search and rescue vehicles; and emergency robots for fighting fires, handling hazardous materials and defusing bombs. JPL is currently developing the suspension for improved mobility to enable robots to clear standard stair steps and travel over dry sand.

## Silica Aerogel Insulation

One of the world's best insulations because of its remarkable properties, silica aerogel, is critical in keeping the Pathfinder's vital electronics at proper operating temperature. It shows great promise in numerous commercial venues, such as refrigerators, delivery boxes for cold or hot food, thermos bottles, ice chests and cold-weather protection in extreme climates. Silica aerogel is the electronics insulation material in the Pathfinder rover's warm equipment box when surface temperatures at Ares Vallis plunged to approximately -100 degrees Fahrenheit every night, making proper operating temperatures critical to the mission.

JPL is exploring ways to commercialize silica aerogel because of its structural and insulating properties. Even though aerogel is processed from silica and is chemically identical to glass, its frothy molecular structure gives it a specific density only a few times that of air. Properly supported, aerogel can bear up to a thousand times its own weight. JPL is currently using aerogel in the Stardust spacecraft to catch high-velocity cometary and interstellar dust particles without contact vaporization.

## DARTS (Dynamics Algorithms for Real-Time Simulation)

One of the new software packages used on the Mars Pathfinder, DARTS (Dynamics Algorithms for Real-Time Simulation), just won NASA's 1997 Software of the Year Award (SYA). The software has saved NASA millions of dollars. Although it is too new to realize its commercial applications,

NASA officials give praise and promise for its applications in space and other research fields.

Written by the JPL team of Abhinandan Jain, Guillermo Rodriguez and Guy K. Man, DARTS generates real-time simulations to test and verify flight software and hardware for a variety of spacecraft missions. The spatial operator algebra, developed in 1991 and a 1994 SYA winner, has improved fidelity and speed processing 10 million times faster than prior versions of such software.

The software is being called "cutting edge" by NASA officials and other industry professionals, explaining why potential commercial applications have not yet been explored. Its potential is every three-dimensional animation program in existence or to be developed, officials say, because it will model the program better than any other software. It has saved NASA more than \$10 million to date—on the Galileo, Cassini, Stardust, New Millennium and Neptune Orbiter missions.

The pharmacy research field has begun to use DARTS in pharmacokinetics, which studies the

chemical and biological effects and reactions of drugs within the body, as well as in studying the cell level and DNA. In the molecular dynamics field, it is being adapted at Caltech to develop

software, called NEIMO, for simulation and analysis of large-scale molecular systems in protein folding, drug design, catalysts, virus mechanisms and other applications of how molecules move through space.

Some possible commercial applications are in what professionals dub "the movement industry"—transportation, automobile design and helicopters. The software could theoretically be applied to the entertainment industry, but officials say that is unlikely because the three-dimensional artistic approach is used in that area.

## Piezoelectric Ultrasonic Motor

The ultrasonic solid-state motor planned for the robotic arm actuator on future Mars missions uses piezoelectric crystals instead of electromagnets, allowing it to work at temperatures near -240 degrees Fahrenheit, while featuring high

THE MARS PATHFINDER HAS EMERGED AS  
THE QUINTESSENTIAL MODEL FOR NASA'S  
FASTER, BETTER, CHEAPER PARADIGM.

reliability and low-power requirements. Its potential consumer uses include computer disc drives, automobile windshields, power windows and wipers, and actuators for microsurgical manipulators.

### Microhygrometer

A microhygrometer, intended for possible use on the Mars '98 lander, was developed at JPL to measure humidity above the surface and in the soil. The size of a quarter, it combines a surface acoustic-wave device cooled with a tiny, two-stage thermoelectric cooler monitored with a co-mounted temperature sensor. Dramatically smaller than current hygrometers, this low-mass, low-power device responds more accurately and faster than conventional, state-of-the-art chilled-mirror hygrometers.

The combination of accuracy, sensitivity, low mass and volume, low-power requirements and rapid response makes for easier delivery and wider broadcast than ever before. The microhygrometer can track sudden changes in weather by measuring rapid humidity changes, and it can map atmospheric gradients from moving probes. This makes possible missions that were once thought inconceivable, such as more economical weather networks or three-dimensional atmospheric profiles.

### Lightweight Carbon Composite

The robotic arm on the Mars '98 lander depends on the strong, machinable, three-dimensional carbon composite used in all critical load-bearing assemblies. Owing much to novel fabrication techniques developed at JPL, the composite weighs half as much as aluminum or the carbon composite materials now in current use, enabling lighter spacecraft and potentially lighter consumer products to be developed.

The new carbon composite is fabricated from very thin, very flat sheets that yield superior strength and stiffness compared to conventional, fabric-based composites. This innovative material sustains high friction with low wear, shows low thermal expansion, resists very high temperatures, is quite immune to the effects of high radiation and is chemically inert. Potential uses are in brakes, drive-train components and high-temperature structural elements. ✱

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For more information on the Mars Pathfinder mission, contact Alice Wessen at the Jet Propulsion Laboratory. ✱ 818/354-4930, ) [Alice.S.Wessen@jpl.nasa.gov](mailto:Alice.S.Wessen@jpl.nasa.gov) For information assistance with the Mattel Hot Wheels Sojourner JPL Mars Rover Action Pack toy, contact Joan Horvath at JPL. ✱ 818/354-7431, ) [joan.c.horvath@jpl.nasa.gov](mailto:joan.c.horvath@jpl.nasa.gov) Please mention you read about it in [Innovation](#).

### SOFTWARE MAY CORRECT AERIAL IMAGERY

**N**ASA/MSU Techlink, a new NASA technology commercialization center at Montana State University–Bozeman, has brokered its first technology transfer agreement. This agreement is between a Montana high-tech firm and NASA's Stennis Space Center to jointly develop software to correct image-related problems in aerial and satellite imagery using existing NASA algorithms.

Engineers from Positive Systems of Whitefish, Montana, hope to develop software that would work with existing high-resolution computer processing to reconcile different image intensities caused by continuously changing sun angles, which can lead to false interpretation. The entire remote-sensing industry could benefit from the solution, according to Positive Systems vice president Cody Benkelman.

Positive Systems produces high ground-resolution airborne imaging systems that acquire digital images rather than the film-based photos of conventional aerial photography, allowing ease of analysis by computer for a wide variety of contracted clients. "Through computer processing, we can clearly recognize objects on Earth that may be less than one meter in size," Benkelman said.

Established a year ago with the help of Montana Senator Conrad Burns, NASA/MSU Techlink makes it easier to transfer NASA and other federally developed know-how to companies in Montana and surrounding states.

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For more information, contact Peter Perna at NASA/MSU Techlink Center. ✱ 406/994-6687, ) [pperma@montana.edu](mailto:pperma@montana.edu) Please mention you read about it in [Innovation](#).

# ADVANCED TECHNOLOGIES

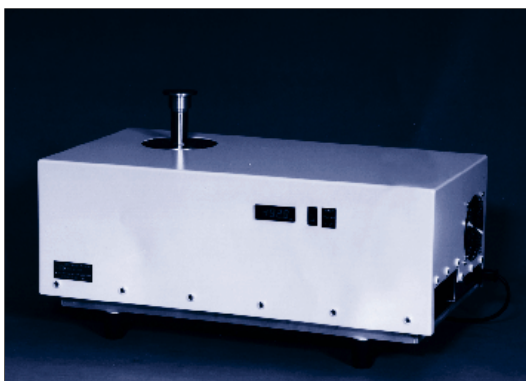
## No Sweat for BeCOOL™

**S**TIRLING TECHNOLOGY COMPANY (STC) OF Washington, D.C., has carved out a niche in a broad cryogenic cooling market with its low-cost, high-efficiency cryogenic cooler, called BeCOOL™, in collaboration with NASA's Goddard Space Flight Center. By meeting the challenge of limiting constraints placed on all NASA hardware development contracts, STC was able to produce new techniques and processes that solved the problems of earlier coolers, including cost and mechanical, and applied them to broad commercial markets with increased demand in the computer manufacturing and high-temperature superconductor areas.

"Broad commercial markets are opening for long-life, maintenance-free and compact cryogenic coolers in the telecommunication, computer, and scientific equipment fields," said Barry Penswick, technical director in charge of new product development for STC. "There were a number of things that were expensive on earlier coolers such as the motor, and also the way it was put together. The new cryogenic cooler takes care of these problems. The flexural bearing, for example, provides a way to keep the moving components from rubbing against each other, which would normally cause wear and then failure. This feature eliminates that high cost of frequent repair."

BeCOOL™ can operate over a broad range of cryogenic temperatures with cooling capacity up to 15 watts. Computer manufacturers have taken advantage of the cryogenic cooling capacity because semiconductor materials work better at lower temperatures. Also, interest in improving computer system performance and increased chip density is putting more demand on innovative ways to cool the central processing unit (CPU). Cooling the CPU to 80 degrees Kelvin can more than double the system's processing speed.

The high-temperature superconductor is a growing market for cryogenic cooling, benefiting products that are cooled with liquid nitrogen temperatures. This application increases performance in a shoe-size box instead of the previous filters the size of a four-drawer filing cabinet. In this case, traditional cryogenic coolers are often too large or place unwanted demands on the end user. Because BeCOOL™ has more than twice the efficiency of industrial coolers, the company can offer a much smaller product.



*The BeCOOL™ cryogenic cooler is a compact, maintenance-free, low-cost alternative to previous commercial coolers.*

Combined with its maintenance-free, long operating life and compact machine, STC coolers are an attractive alternative to traditional cryogenic coolers because they operate for more than 50,000 continuous hours. STC is currently manufacturing a line of free-piston Stirling cryogenic coolers for multiple commercial markets. Penswick said that companies across the nation have demonstrated a high level of interest in the cryogenic coolers. \*

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For more information, contact Barry Penswick at Stirling Technology Company.  
& 509/735-4700, ) [bpenswick@stirlingtech.com](mailto:bpenswick@stirlingtech.com) Please mention you read about it in *Innovation*.

## Invisible, Tamper-Resistant Bar Codes

**D**IGITAL DATA MATRIX TECHNOLOGY USED to identify the millions of Space Shuttle parts, including those on *Endeavour*, is being commercialized to make bar-coding tamper resistant and invisible to the naked eye. This technology is filling a growing commercial industry need for an identification system that can be placed directly on a product, regardless of various properties such as shape, size and color.

The invisible and virtually indestructible laser-etched markings, applied directly to the product, range in size from four microns to two square feet, and they are seen as the next generation of the already familiar product "bar codes." Traditional bar codes are not tamper resistant. They can only be used on paper or plastic packaging and on stickers and labels.

## ADVANCED TECHNOLOGIES

*Donald Roxby, director of the new Symbology Research Center, Huntsville, Alabama, inspects a sample of automotive glass engraved with a digital matrix identifier code.*



*The number and type of commercial products now using the digital matrix identifier codes are expanding daily.*



Production began in August in Huntsville, Alabama, at Symbology Research Center, a partnership between NASA's Marshall Space Flight Center and bar-code industry leader CiMatrix Corporation of Massachusetts. Marshall began examining the possibility of developing a paperless identification system (digital data matrix technology) in 1986 because the paper-imprinted bar coding could not survive the high heat during space flight and was not adhering to the Space Shuttle thermal tiles, says Marshall engineer Fred Schramm, who is working on the project with Symbology Research Center Director Donald Roxby. Digital data matrix technology proved effective in the demanding space flight environment.

In 1991, NASA determined that converting to digital data matrix coding would save \$1 million a year on the orbiter fleet alone, Roxby said. Industries view the new system as a means of complying with new federal requirements of including more content information on labels, he said. Where space is at a premium and bar coding the information onto the product is impractical, digital data matrix technologies offer a solution, according to Roxby. Paper bar coding will continue to have uses in many industries, Roxby said, but digital data matrix technologies hold the solution when the identification of a small part is essential or where the paper bar coding could deteriorate.

Many other industries, including electronic parts, pharmaceuticals and livestock, are expressing interest in the new system. As industry demands increase, the Huntsville center will serve as the prototype for additional centers across the country and around the world. More opportunities to use the new product coding system will be explored while Roxby and his staff expect to handle up to 500 product marking problems each annually. ✱

For more information, contact Fred Schramm at Marshall Space Flight Center.  
& 205/544-0823, 205/544-5890, Harry.F.Schramm@msfc.nasa.gov  
Please mention you read about it in *Innovation*.

## Space Device May Assess Bone Density

A PORTABLE DEVICE THAT MEASURES THE relationship between bone density and physical activity in space may someday serve as a way to assess a person's risk of osteoporosis. The device, developed by NASA's Ames Research Center, Moffett Field, California, provides a record of "loading"—the major force people apply to their bodies throughout the day—by measuring and recording the force that occurs on the foot during each step. Loading is important in maintaining muscle and bone strength in the lower limbs.

This force, or "loading," can reach one and one-half times a person's body weight during walking and two to three times the body weight during running, according to Dr. Robert Whalen, head of the Musculoskeletal Biomechanics Laboratory in the Gravitational Research Branch at Ames. If muscles and bones are not used, they become significantly weaker—a problem encountered by astronauts during space flight. "With current in-flight exercise devices, it is difficult to achieve force levels equivalent to levels achieved during normal daily activity on Earth," Whalen said. "We are investigating new ways to counteract these changes with devices capable of imposing Earth-equivalent levels of force on the body in space."

The device is a force sensor, resembling a shoe insole, connected by a cable to a small computer carried in a fanny pack, which is capable of storing about two weeks of activity data. The computer samples the applied force 100 times per second. It stores only the significant maximum and minimum forces occurring



during each loading or gait cycle, as well as the peak loading and unloading rate and the time at which each event occurred.

The key, Whalen explained, is determining how individuals can “load” their bodies to maintain muscle and bone strength. Because our muscles generate their own forces, we are limited by how strong our muscles are. “If you don’t have the muscle strength, you can’t exert high forces on bones to increase bone mass,” Whalen said. “As people age, a gradual decline in activity level and intensity contributes to a decline in muscle strength, and therefore our ability to load our bones also decreases,” resulting in weaker, less dense bones that are more prone to fractures.

This device will allow for the measurement of an individual’s activity to assess his or her risk of low bone density from a low physical activity level. It will allow an individual exercise prescription to improve the health of an older person. ✱

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For more information, contact Dr. Robert Whalen at Ames Research Center.  
& 415/604-3280, ) [rwhalen@mail.arc.nasa.gov](mailto:rwhalen@mail.arc.nasa.gov) Please mention you read about it in *Innovation*.

## Robot Paves the Way for More Missions

**F**UTURE SCIENTIFIC SPACE EXPLORATION missions to Antarctica, the Moon and Mars look promising after a four-wheel-drive roving robot explored the terrain of Chile’s rugged Atacama Desert for 45 days. The rover named Nomad set travel records and exceeded expectations of scientists at NASA’s Ames Research Center and Carnegie Mellon University in Pittsburgh.

Nomad traveled 133 miles, more than any remotely controlled robot has ever done over rough territory, driving 12 of those miles totally on its own—an important objective called autonomous driving. A rock retrieved by Nomad, seen initially by scientists as a simple rock through Nomad’s panoramic camera, turned out to be an undiscovered rock deposit from the Jurassic period, confirming the use of human-eye resolution cameras for geology. A separate panospheric camera returned more than a million video panoramas from the desert’s cold arid region, located 7,000 feet above, confirming the benefits of immer-

sive, hemispheric imagery for remote control, peripheral vision driving for space exploration.

“This is a quantum leap for the planetary robotics culture,” said principal investigator Dr. William L. “Red” Whittaker of Carnegie Mellon. The historical standard of robotic travel has been yards, not miles, and autonomous driving is critical for planetary exploration.

The communications delay between Earth and planets can be many minutes, and a robot can explore a much greater distance because it is able to see and recognize obstacles on its own and does not have to depend on a person to decide a safe route, according to Dr. Mark Maimone, Nomad software and navigation lead at Carnegie Mellon.

The 1,600-pound robot is the size of a small car and travels at the speed of one mile per hour on a gasoline-powered generator. Its chassis expands for improved travel over various terrain conditions, and its four aluminum wheels provide traction in soft sand.

During different phases of testing, the robot was put through various simulations for wide-area exploration of the Moon, the search for past life on Mars and the gathering of meteorite samples in the Antarctic, according to officials at NASA Headquarters in Washington, D.C. NASA and Carnegie Mellon are formulating plans to use Nomad to look for meteorites in Antarctica in 1998 and 1999.

The total \$1.6 million cost of developing Nomad and conducting the desert trek was funded by NASA with in-kind support from corporate sponsors and educational foundations. ✱

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For more information, contact David S. Wettergreen at Ames Research Center.  
& 415/604-2257, ) [David.S.Wettergreen@arc.nasa.gov](mailto:David.S.Wettergreen@arc.nasa.gov) Please mention you read about it in *Innovation*.



*“Nomad” the rover created a new standard for robotic travel and paved the way for future space exploration to Antarctica, the Moon and Mars after traveling 133 miles, more than any other remote-controlled robot, in recent rough tests.*

# AEROSPACE TECHNOLOGY DEVELOPMENT

## Data Tool May Revolutionize Airplane Testing and Design

**A** NASA COMPUTER NETWORK TOOL BEING tested at Ames Research Center could revolutionize the design, testing and construction of airplanes. The device could shorten the process by 25 percent and eliminate retesting by providing more accurate and readily accessible information.

The tool, called "Darwin," funnels wind tunnel data into a server computer and sends knowledge

back in "near real time"—within about 30 seconds to five minutes—to researchers at NASA, at academic centers and in the aerospace industry—all located hundreds or thousands of miles from one another but linked to the computer system. "Darwin" is hooked to wind tunnels, the airflow test chambers where air is blown around airplane and rocket models to simulate flight. New knowledge about airplane designs gained during wind tunnel tests helps engineers know whether their ideas are working or whether design changes must be made before expensive, full-size prototype airplanes are built.

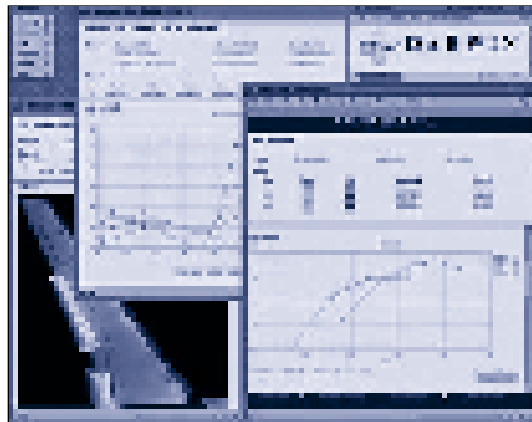
Pressure gauges, strain gauges and other instruments attached to the models take readings while air blows through the wind tunnels during experiments. Data streaming from the model instruments tell aerospace engineers how much lift, drag and maneuvering performance an airplane model can generate through different angles of flight and at various speeds, altitudes and conditions.

"Testing a model in a wind tunnel, you get actual physics because you have real wind blowing over a wing," Dr. David Korsmeyer, deputy project manager, explained. Darwin collects data, translates the information into an easily understood format and provides access to researchers, simultaneously and securely, according to Korsmeyer. "Before we began to use large computer networks to deliver data, wind tunnel systems were very good at capturing data for later

analysis, but they were not good at immediately 'serving' the data," he said. "Previously, such knowledge had to be derived by scientists and engineers in the days and months following wind tunnel tests."

Aerospace models used in the tunnels can exceed \$1 million each because they must be exactly to scale and extensively instrumented. Running a large wind tunnel can cost tens of thousands of dollars per hour,

*Darwin is a computer network tool that promises the return of wind tunnel testing data in "near real time," providing a great savings in time and money for the aircraft design and construction industry.*



with the exact cost depending on the tunnel, the number of personnel needed and any special equipment required. Engineers would prefer not to have to return to a tunnel for follow-up test cycles with modified airplane or spaceship models. ✱

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For more information, contact David Korsmeyer at Ames Research Center.  
& 415/604-3114, ) [dkorsmeyer@mail.arc.nasa.gov](mailto:dkorsmeyer@mail.arc.nasa.gov) Please mention  
you read about it in [Innovation](#).

## High-Altitude Pathfinder Missions Are Closer

**A**SLEEK, SOLAR-POWERED, REMOTELY piloted vehicle named Pathfinder has moved NASA closer to fulfilling growing scientific requirements to use unpiloted aircraft at higher altitudes to obtain various types of scientific data than is possible with NASA's current data-gathering fleet of remotely piloted vehicles. Pathfinder spent this past summer at the U.S. Navy Pacific Missile Range facility in Kauai, Hawaii, where it set a new unofficial world record for high-altitude flight by a solar-powered aircraft. It reached more than 71,500 feet, exceeding its own previous record of 67,350 feet.

"The altitude achievement, a major milestone for the program, demonstrates the aircraft's capability to carry scientific payloads and other experiments into the upper atmosphere," said Jennifer Baer-Riedhart, project manager for NASA's Environmental Research Aircraft and Sensor Technology (ERAST) program at the Dryden Flight Research Center in Edwards, California.

Similar remotely piloted aircraft could spend long periods of time over the ocean monitoring storm developments to provide more accurate predictions of hurricanes. These aircraft also could be used to monitor major croplands, forests and other large, remote expanses to provide early warning of crop damage or fires.

Pathfinder is one of several remotely piloted aircraft being evaluated under ERAST. The program focuses on developing technologies required to operate slow-flying unpiloted aircraft at high altitudes.



*Solar-powered Pathfinder sets a new unofficial world record for high-altitude flight.*

The most extreme mission envisioned for solar-powered aircraft would reach altitudes of 100,000 feet for environmental sampling missions that last a week or longer. Additional technologies to be considered for NASA's high-altitude program include lightweight materials, avionics, sensor technology, aerodynamics and other forms of propulsion suitable for extreme altitudes.

Pathfinder, a flying wing spanning 99 feet, with two small pods that extend below the wing's center section, can carry a variety of scientific sensors. The solar arrays on the wing can provide as much as 7,200 watts of power at high noon on a summer day to power the craft's six electric motors and other electronic systems. A backup battery system

can provide power for up to five hours to fly the craft after sundown.

Pathfinder was designed and manufactured and is operated by AeroVironment, Inc., of Simi Valley, California, under a jointly sponsored research agreement with NASA. ✱

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For more information, contact Jenny Baer-Riedhart at Dryden Flight Research Center. ✱ 805/258-3689, ) [jenny.baer-riedhart@mail.dfrc.nasa.gov](mailto:jenny.baer-riedhart@mail.dfrc.nasa.gov)  
Please mention you read about it in *Innovation*.

## Next-Generation Rocket Engine Advances

**A** CRITICAL SERIES OF TESTS ON A ROCKET engine that could power the next generation of space launch vehicles has been successfully completed at the Marshall Space Flight Center in Huntsville, Alabama. The Fastrac engine—only the second American-made engine developed in the last 25 years—will be the primary propulsion system for the X-34 technology demonstration vehicle scheduled to begin flight tests in late 1998.

The X-34 is next in NASA's series of Reusable Launch Vehicle (RLV) technology demonstrators set for up to 25 flights beginning late next year. The

X-34, an air-launched vehicle, is intended to demonstrate technologies ranging from composite structures and reusable propellant tanks and insulation to advanced thermal protection systems and low-cost avionics.

X-34 demonstrations will precede the more advanced X-33 technology demonstrator scheduled to begin flights up to Mach 15 in mid-1999. A major goal of NASA's RLV efforts is to reduce dramatically the cost of putting payloads into space.

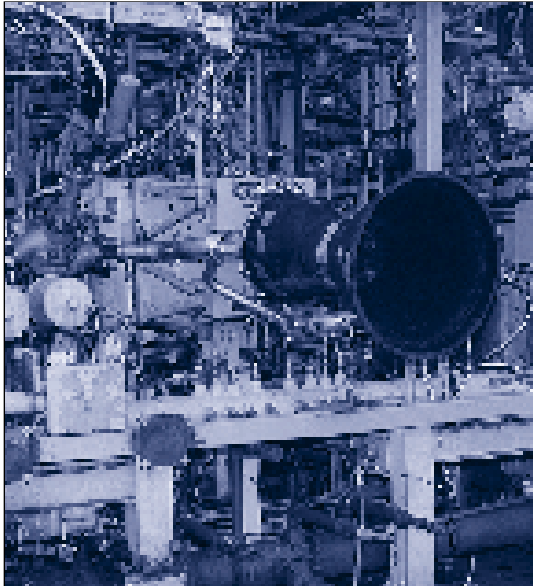
Recently completed Fastrac engine component tests evaluated the engine's thrust chamber assembly at high pressure almost identical to flight conditions. "The thrust chamber assembly performed as designed, which is another indication that the Fastrac is an engineering breakthrough," said George Young, Fastrac engine chief engineer. "Marshall engineers developed this engine in a much shorter-than-usual design cycle at significantly lower costs than a typical rocket engine."

The Fastrac engine uses simple open-looped control to minimize the expense of control valves and electronics. The engine thrust chamber is made of silica-phenolic ablative material overwrapped with graphite fiber. This part can be manufactured using commercial techniques at a much lower cost than typical tube-type thrust chambers. The engine injector has been simplified to include only three parts, a two-piece injector body and a brazed-on copper faceplate.

*Marshall Space Flight Center engineers conduct a series of tests evaluating the main propulsion system for the 1998 X-34 demo flight tests, which have been successfully completed in near-identical flight conditions.*







*The Fastrac engine is being called "an engineering breakthrough" after its thrust chamber assembly performed successfully. Designers developed the engine in record time at lower costs.*

Each Fastrac engine initially will cost approximately \$1 million—about one-fourth the cost of similar engines. The Fastrac provides 60,000 pounds of thrust and, in addition to the X-34 vehicle, is targeted for launch systems designed to boost payloads weighing up to 500 pounds at a dramatically lower cost. ✨

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For more information, contact Daniel Davis at Marshall Space Flight Center. & 205/544-0034. ) [Daniel.J.Davis@msfc.nasa.gov](mailto:Daniel.J.Davis@msfc.nasa.gov) Please mention you read about it in [Innovation](#).

## General Aviation Group Reports Progress

**L**EADERS OF THE ADVANCED GENERAL Aviation Transport Experiment (AGATE) Alliance are reporting impressive progress in their effort to revitalize the nation's light plane industry, developing technologies that promise safe, affordable and convenient personal air transportation. AGATE is a pact between government and the U.S. light plane industry to revitalize general aviation in this country, working to make airplanes as easy to operate as cars. The following are project examples of AGATE's efforts.

### New Pilot Training Methods Develop

With support from NASA, the Federal Aviation Administration (FAA) is developing a training curriculum that will be integrated into AGATE glass cockpit training methods in the next few years. It calls for creating learning modules for glass cockpit multifunction displays and single-lever power control systems. It also includes a curriculum that could cut certification costs by 25 percent for nonpilots to obtain an instrument rating.

The project's cost will be evenly split between government and industry. NASA is funding the government's \$1.5 million share the first year, while the FAA plans to fund the government's share for the remaining years of the effort.

Team members to date include Advanced Creations, Inc., Dayton, Ohio; Cessna Aircraft Company, Wichita, Kansas; Florida Institute of Technology, Melbourne, Florida; Jeppesen Sanderson, Englewood, Colorado; and Raytheon Aircraft, Kansas. Agreements are being negotiated with other potential members.

### New Datalink Radio Demonstrated

An AGATE Alliance member company has successfully demonstrated a digital datalink radio using affordable technologies for retrofit and future general aviation aircraft. This could lead to reducing weather-related general aviation accidents, the leading cause of light plane fatalities.

The high-bandwidth, software-based digital radio, developed by NavRadio Corporation of Denver, Colorado, has the potential for quickly communicating weather, clearance, flight planning, maintenance and other data. It has enough capacity to bring national and regional aviation weather graphics into the cockpit of general aviation airplanes for display on computer screens.

Datalink radio technology is expected to be available commercially within the next 24 months. The technology is expected to play a key role in enabling the FAA's "free flight" concept for greater flexibility in user-preferred flight routings.

### New Quiet and Efficient Propeller

A propeller made of space-age composite materials is being hailed as the first major improvement in fixed-pitch propellers for light planes since the 1930's. The propeller, an advanced "quasi-constant speed" propeller, permits a fixed-pitch propeller to perform similarly to a variable-

pitch propeller, but without the complexity of a variable-pitch propeller.

As part of its work in the AGATE Integrated Design and Manufacturing Work Package, Global Aircraft of Starkville, Mississippi, took advantage of

modern aerodynamic technology and advanced composite structural processes to design and develop a composite quasi-constant speed propeller suitable for a typical 150–180 horsepower general aviation engine. The propeller will automatically change pitch by flexure of the propeller blade rather than mechanical rotation of the blade shank.

This technology makes it possible to develop a propeller that is both more efficient and quieter than current metal propellers. Production of the propeller is anticipated to begin in the fall of 1997.

### AVIATION DESIGN WINNERS ANNOUNCED

**N**ASA and the FAA each year award graduate and undergraduate engineering student teams nationwide for designing simulated general aviation technology breakthroughs and applications. The purpose of these awards is to revitalize the industry and provide quality, real-world experience. The following received this year's awards:

- For the first time in the National General Aviation Design Competition's three years, an individual, Princeton University senior Jennifer Wilson, was given the special \$500 award for Greatest Retrofit Potential, sponsored by the Aircraft Owners and Pilots Association's Air Safety Foundation.
- The first place award, \$3,000 for the team and \$5,000 divided among universities, was given a second time to the University of Kansas, Wichita State University and Kansas State University. They designed a low-cost, four-passenger kit plane, reportedly comparable to a Cessna 172R, using pre-assembled/prefabricated structures to minimize construction time. This was in response to a revised FAA rule that kit-type planes be 50 percent built by the owner without prefabrication.
- The Pennsylvania State University won the \$2,000 second place award with critical acclaim for a well-engineered, realistically priced, high-performance aircraft that very well targets general aviation revitalization goals.
- The \$1,000 third place prize was awarded to Virginia Polytechnic Institute for designing an energy-efficient, environmentally friendly sport utility aircraft that can take off and land on water.

For more information, contact Mary Sandy at Virginia Space Grant Consortium. & 757/865-0726, ) msandy@pen.k12.va.us  
Please mention you read about it in [Innovation](#).

### Nonprofit AGATE Corporation Established

John F. Sheehan, president of Business Development Systems, Inc., has been named as executive director of the newly established AGATE Alliance Association, Inc. (AAAI). This nonprofit organization was established by the industry members of the AGATE Alliance as a means for conducting administrative and managerial business. The organization, created by the AGATE Executive Council, located in Hampton, Virginia, is expected to provide the AGATE Alliance with greater flexibility. AAAI also maintains the AGATE web site at <http://agate.larc.nasa.gov> ✨

For more information, contact John F. Sheehan at AGATE Alliance Association, Inc. (AAAI). & 757/766-7512. Or contact Keith Henry at Langley Research Center. & 757/864-6120. Please mention you read about it in [Innovation](#).

## Turbofan-Powered Aircraft Expected to Revive Aviation

**N**ASA HAS PARTNERED WITH THE GENERAL aviation industry in introducing the V-JET II, a turbofan-powered light aircraft designed for future flight testing. It is expected to revolutionize and revitalize general aviation with a safer, smoother, quieter and more affordable light aircraft.

"The V-JET II marks a turning point in general aviation," NASA Administrator Daniel S. Goldin said when he joined Williams International Chairman Dr. Sam Williams at the 45th Annual Experimental

Aircraft Association (EAA) International Fly-In held recently in Oshkosh, Wisconsin, to demonstrate the V-JET II. Dr. Williams added, "Our objectives are to develop the quietest and least polluting propulsion system in aviation as well as the lightest weight turbine propulsion system for manned aircraft. We also expect to be able to price these engines low enough to stimulate the rapid expansion of the light aircraft industry in the United States."

Williams provided the aircraft for use in the General Aviation Propulsion (GAP) program. It will demonstrate breakthrough, low-cost turbine-engine propulsion systems for light general aviation aircraft with cruising airspeeds greater than 200 knots.

Built by Scaled Composites of Mojave, California, and designed by Williams International of Walled Lake, Michigan, the V-Jet II features its new FJX-2 turbofan engine, which is being developed under a GAP Cooperative Agreement. The aircraft will demonstrate the new FJX-2 turbofan engine over a range of flight speeds and altitudes that are expected to be required in future turbofan-powered light aircraft.

"With the new engines being developed in the GAP program, general aviation will take a signifi-

cant leap forward," said Leo Burkardt, GAP program manager at NASA's Lewis Research Center in Cleveland. "The V-JET II gives us a glimpse at the exciting revolution in light aircraft that the GAP engines will make possible."

The aircraft currently is being powered by two existing low-bypass-ratio, 550-pound-thrust FJX-1 turbofan engines, developed earlier by Williams International. These interim engines will be used to evaluate the aircraft's performance and systems prior to the installation of the FJX-2 engines. Flight tests of the FJX-2 engines will occur by the year 2000.

NASA's GAP program is aimed at revitalizing general aviation by uniting propulsion and airframe manufacturers—and other industries—with government to develop and demonstrate new general aviation propulsion systems. Future aircraft will utilize commercial versions of these revolutionary engines to make future light aircraft safer, smoother, quieter and more affordable. ✨

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For more information contact Leo Burkardt at Lewis Research Center.

& 216/977-7021, ) [leo.burkardt@lerc.nasa.gov](mailto:leo.burkardt@lerc.nasa.gov) Please mention you read about it in *Innovation*.



*The V-Jet II, an all-composite, turbofan-powered light aircraft, was designed by Williams International of Walled Lake, Michigan, to demonstrate its new FJX-2 turbofan engine, which is being developed under a General Aviation Propulsion (GAP) program Cooperative Agreement.*

# SMALL BUSINESS/SBIR

## All Occupants Survive Crash Test

**A** NASA SMALL BUSINESS INNOVATION Research program contractor successfully crash-tested a small airplane designed to protect occupants against fatal injuries using airbags and energy-absorbing composite structures. All of the crash dummies on board in the

final test "survived" the crash, a first for general aviation crash tests.

Terry Engineering of Wichita, Kansas (with the help of Cirrus Design Corporation of Duluth, Minnesota, and NASA's Langley Research Center in Hampton, Virginia), has crash-tested a total of four airplanes over a two-year period at typical impact speeds of 60 mph involving earth and hard surfaces. The tests also successfully demonstrated an improved shoulder harness system and energy-absorbing seats.

The goals of the program were to apply the techniques, which have been successfully applied in military helicopters, race cars and modern automobiles, to improve the survivability in crashes of small composite airplanes and to reduce injury severity in survivable crashes.

The program used a combination of analysis, subscale quasi-static testing and full-scale crash-testing to achieve these goals, which were highlighted at a recent

joint meeting of NASA, the Federal Aviation Administration (FAA) and the Advanced General Aviation Transport Experiment (AGATE), a U.S. light plane industry group working with the U.S. government to revitalize general aviation and make planes easier to operate. ✱

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For more information, contact Keith Henry at Langley Research Center. & 757/864-6120, ) [H.K.Henry@larc.nasa.gov](mailto:H.K.Henry@larc.nasa.gov) Please mention you read about it in *Innovation*.

## Past SBIR/STTR Winners Showcase Research

**S**OME PAST AWARDEES FROM NASA'S SMALL Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs showcased their developed technologies at the 45th Annual Experimental Aircraft Association International Fly-In in Oshkosh, Wisconsin.

NASA began providing funding for high-risk, high-payoff innovative technical research in 1983. Since then, nearly \$900 million has been given to more than 1,600 U.S. firms to successfully commercialize their winning research to create jobs and new industries, as well as to generate revenue for the nation's economic benefit. Small businesses compete for awards based on projects that lead to commercial products and that are within the scope and support of NASA's mission. Since 1993, NASA has invested more than \$23 million in general aviation SBIR and STTR awards.

One of the showcased SBIR/STTR awardees was Mod Works. These retrofit experts developed technology for integrating emerging cockpit systems into existing airplanes, resulting in an easy installation that was safer, more advanced, more ergonomic and less expensive and that achieved FAA certification. Mod Works collaborated with the Florida Institute of Technology in combining nine separate engine gauges into one integrated system.

Aurora Flight Sciences developed the single-lever power control technology, which offers pilots reduced workload, improved safety and optimal engine control, based on the specific flight condition. The technology can be used in conjunction with advanced health monitoring and fault-tolerant control systems.

### 1997 STTR PHASE I SELECTIONS

**N**ASA's Office of Aeronautics and Space Transportation Technology has selected 50 research proposals for Phase I contracts in the agency's 1997 Small Business Technology Transfer (STTR) program. More than 200 separate proposals were submitted by small high-technology businesses from across the United States.

The 50 selected proposals each will receive a fixed-price contract valued up to \$100,000 with one year to complete the Phase I projects. Companies successfully completing Phase I activities can compete the following year for Phase II awards—two-year, fixed-price contracts up to \$500,000.

A Phase I project must determine the feasibility of proposed research. To qualify, small businesses must partner with a research institution to conduct cooperative research and development. At least 40 percent of the work must be performed by the small business concern, with at least 30 percent by the research institute.

All proposals were peer-reviewed for both technical merit and commercial potential based on the following four evaluation criteria:

- Scientific or technical merit and feasibility of the proposed cooperative research effort
- Experience and qualification of the small business concern
- Effectiveness of the proposed organization and plans for accomplishing the goals of the cooperative research
- Commercial merit and feasibility of the proposed research

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For a listing of the winners, visit <http://ftp.hq.nasa.gov/pub/pao/pressrel/1997/97-152a.txt>



The system has been extensively tested in Aurora's Manassas, Virginia, facilities, and evaluation for general aviation applications has commenced.

Global Aircraft Company designed the quasi-constant speed composite propellers to provide advantages over fixed-pitch propellers without incurring the complexity of constant speed propeller governors and controls. These propellers increase static and takeoff thrust for shorter takeoff distances, increase rate of climb and/or maximum useful load, increase propeller efficiency at cruise speed and reduce cabin and community noise.

Ballistic Recovery Systems, Inc., is seeking to develop new technologies to reduce the weight and bulk of parachute canopies, using new materials and design, for recovering the whole airplane in an emergency situation. The safety provided will increase the utility of general aviation aircraft.

Seagull Technology, in partnership with Stanford University, developed a low-cost, solid-state attitude and heading reference system to provide pilots with an affordable and expandable situational awareness solution in the cockpit. This is a multifunction display system that combines navigation, traffic, weather and scene management information in one integrated display. ✨

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For more information, contact Thayer Sheets at Langley Research Center.

✉ 757/864-2487, ) [r.t.sheets@larc.nasa.gov](mailto:r.t.sheets@larc.nasa.gov) Please mention you read about it in *Innovation*.

## Aircraft May Operate Like Cars

**A**IRCRAFT COULD BE AS EASY TO OPERATE AS an automobile through the participation of a Virginia developer in NASA's Small Business Innovation Research program. Aurora Flight Sciences of Manassas, Virginia, took the complex system of multiple control levers and gauges and replaced them with a single-lever power control technology and single display in an effort to achieve the advantages of single-lever power control systems, such as increased engine performance and fuel efficiency and substantially reduced pilot workload.

Aurora completed the first successfully flown flight using a single-lever control in a modified



*In current general aviation aircraft, several levers are used for engine power control (as seen on center console unit).*

Cessna 02-A. The company's device took the three standard engine control levers—throttle, fuel-air mixture and propeller pitch angle—and had them performed by a computer referred to as a single-channel full-authority digital engine control, making an air-cooled aircraft engine work much like the accelerator pedal in an automobile.

Cessna Aircraft will soon be flight-testing its modified Cessna 182 RG with a mechanical single-lever power control connecting the throttle with the propeller. A dual-channel engine control is used to control the electronic ignition and fuel injection.

This technology is being developed by the ten industry members of the Propulsion Sensors and Controls Work Package of the Advanced General Aviation Transport Experiment (AGATE) to revitalize general aviation in this country through an alliance between government and the U.S. light plane industry. NASA's Lewis Research Center is managing the effort to develop guidelines, standards and certification methods for engine controls and diagnostics. ✨

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For more information, contact Lori Rachul at Lewis Research Center.

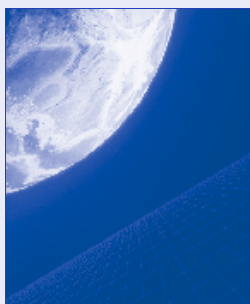
✉ 216/433-8806, ) [eatrue@popservice.lerc.nasa.gov](mailto:eatrue@popservice.lerc.nasa.gov) Please mention you read about it in *Innovation*.



*The use of a single lever for power control in retrofitted and future aircraft reduces the number of flight-related displays in the instrument panel, thus increasing pilot awareness.*

# TECHNOLOGY OPPORTUNITY SHOWCASE

Moving Forward



**Technology Opportunity Showcase** highlights some unique technologies that NASA has developed and which we believe have strong potential for commercial application. While the descriptions provided here are brief, they should provide enough information to communicate the potential applications of the technology. For more detailed information, contact the person listed. Please mention that you read about it in *Innovation*.

## Fiber-Optic High-Temperature Sensor System

SENTEC Corporation and NASA's Lewis Research Center seeks a commercialization partnership or licensing agreement for the fiber-optic high-temperature sensor. It has the potential to operate within and monitor temperatures from 0 to more than 800 degrees Celsius in harsh environments, covering the entire required propulsion system control temperature. It is compact, lightweight, immune to electromagnetic interference and much more reliable than other optical sensors.

White light travels between an optical fiber and a metal surface, encountering a Fabry-Perot interferometer, sending back a reflected white light interference fringe that travels to a spectroscopic detector. This detector is connected to a computer that reads the interference fringes, converting the data into consistent fringe spacing temperatures. Applicable industries include aeronautics, military vehicles and nuclear and industrial power plants. ✱

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For more information, contact Dr. Margaret Tuma at Lewis Research Center.  
& 216/433-8665, ) [mtuma@lerc.nasa.gov](mailto:mtuma@lerc.nasa.gov)

## System Fault Detection and Accommodation

Lewis Research Center seeks to transfer its Fault Detection, Isolation and Accommodation (FDIA) real-time detection technologies for improving system operability, extending the system and minimizing maintenance while maximizing performance. These technologies have been tested and simulated in various aircraft components, such as: a sensor validation scheme processing equal output and original input vector data for an estimated true measurement for the controller; an on-line estimation algorithm for real-time input/output estimated fault parameter data; and use of experts' heuristic knowledge to identify known component faults not covered by other techniques. Potential applications include systems continuously monitored for high performance, such as aircraft engines, automobiles, chemical plants and other automated tasks. ✱

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For more information, contact Dr. Ten-Huei Guo at Lewis Research Center.  
& 216/433-3734, ) [loguo@lerc.nasa.gov](mailto:loguo@lerc.nasa.gov)

## Photonic Switching Using Light Bullets

Ames Research Center seeks a commercial partner, with an interest to license, that has the ability to demonstrate experimentally an invention, Photonic Switching Using Light Bullets, that uses pulses of light

(bullets) to perform higher speed and efficient all-optical switching. This is an essential operation of all communications networks, digital computers and signal processing systems.

NASA researchers have performed computer simulations and developed designs for an all-optical switch made of readily available, relatively inexpensive nonlinear materials, resulting in a performance of low-power, high-speed switching in a small device. Such a device can be easily manufactured using current semiconductor manufacturing techniques. To date, light bullets have been studied only theoretically, and some disagreement exists over the conditions that are necessary for them to exist and function.

The required switching present in communications systems and networks is limiting in speed because only electrical, acoustic or magnetic forms of switching are used. Light bullet switching is a special form of an all-optical switching device called solitons. When these pulses of light propagate in a nonlinear medium, they maintain their shape and are self-guided because of the balance of diffraction, the medium's group velocity dispersion and nonlinear self-phase modulation. This results in a change in each light bullet's direction, transmitting them into predetermined output channels.

NASA sees a major advantage for massive parallelism (in space) and pipelining (in time). The rapid proliferation of information technology in all areas and the ever-increasing power of computers and data storage devices are beginning to fuel a potentially massive demand for network interconnection.

## Contactless Magnetic Slip Ring

Ames Research Center seeks to license for commercial applications the patent pending called Contactless Magnetic Slip Ring. The device transmits reliable and efficient power or data without a conventional slip ring's physical contact between stationary and rotating frames or parts. It uses rotating, inductive components supported by air or mechanical bearings and resists dirt, wear and unwanted arcing. The device requires low maintenance, offers a lower long-term cost and is easily manufactured. Potential commercial applications range from simple toys to sophisticated medical equipment, electrical motors and alternators, such as in helicopter rotors and centrifuges and in situations where there is explosive gas and risk of sparks. ✱

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For more information about the two preceding technologies, contact Cathy Pochel at Ames Research Center. & 650/604-4595, ) [cpochel@mail.arc.nasa.gov](mailto:cpochel@mail.arc.nasa.gov)



## NASA Field Centers

### Ames Research Center

Selected technological strengths are Information Technologies, Aerospace Systems, Autonomous Systems for Space Flight, Computational Fluid Dynamics and Aviation Operations.

### Bruce Webbon

Ames Research Center  
Moffett Field, California 94035-1000  
650/604-6646  
[bwebbon@mail.arc.nasa.gov](mailto:bwebbon@mail.arc.nasa.gov)

### Dryden Flight Research Center

Selected technological strengths are Aerodynamics, Aeronautics Flight Testing, Aeropropulsion, Flight Systems, Thermal Testing and Integrated Systems Test and Validation.

### Eugene (Lee) Duke

Dryden Flight Research Center  
Edwards, California 93523-0273  
805/258-3802  
[duke@louie.dfrc.nasa.gov](mailto:duke@louie.dfrc.nasa.gov)

### Goddard Space Flight Center

Selected technological strengths are Earth and Planetary Science Missions, LIDAR, Cryogenic Systems, Tracking, Telemetry, Command, Optics and Sensors/Detectors.

### George Alcorn

Goddard Space Flight Center  
Greenbelt, Maryland 20771  
301/286-5810  
[george.e.alcorn.1@gsfc.nasa.gov](mailto:george.e.alcorn.1@gsfc.nasa.gov)

### Jet Propulsion Laboratory

Selected technological strengths are Near/Deep-Space Mission Engineering, Microspacecraft, Space Communications, Information Systems, Remote Sensing and Robotics.

### Merle McKenzie

Jet Propulsion Laboratory  
Pasadena, California 91109  
818/354-2577  
[merle.mckenzie@ccmail.jpl.nasa.gov](mailto:merle.mckenzie@ccmail.jpl.nasa.gov)

### Johnson Space Center

Selected technological strengths are Life Sciences/Biomedical, Spacecraft Systems, Information Systems, Robotic and Human Space Flight Operations

### Henry (Hank) Davis

Johnson Space Center  
Houston, Texas 77058  
281/483-0474  
[henry.l.davis@jsc.nasa.gov](mailto:henry.l.davis@jsc.nasa.gov)

### Kennedy Space Center

Selected technological strengths are Emissions and Contamination Monitoring, Sensors, Corrosion Protection and Biosciences.

### Gale Allen

Kennedy Space Center  
Kennedy Space Center,  
Florida 32899  
407/867-6226  
[gale.allen-1@kmail.ksc.nasa.gov](mailto:gale.allen-1@kmail.ksc.nasa.gov)

### Langley Research Center

Selected technological strengths are Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences.

### Joe Heyman

Langley Research Center  
Hampton, Virginia 23681-0001  
757/864-6005  
[j.s.heyman@larc.nasa.gov](mailto:j.s.heyman@larc.nasa.gov)

### Lewis Research Center

Selected technological strengths are Aeropropulsion, Communications, Energy Technology and High Temperature Materials Research, Microgravity Science and Technology and Instrumentation Control Systems.

### John Hairston

Lewis Research Center  
Cleveland, Ohio 44135  
216/433-8686  
[John.M.Hairston@lerc.nasa.gov](mailto:John.M.Hairston@lerc.nasa.gov)

### Marshall Space Flight Center

Selected technological strengths are Materials, Manufacturing, Non-destructive Evaluation, Biotechnology, Space Propulsion, Controls and Dynamics, Structures and Microgravity Processing.

### Sally Little

Marshall Space Flight Center  
Huntsville, Alabama 35812  
205/544-4266  
[sally.little@msfc.nasa.gov](mailto:sally.little@msfc.nasa.gov)

### Stennis Space Center

Selected technological strengths are Propulsion Systems, Test/Monitoring, Remote Sensing and Nonintrusive Instrumentation.

### Kirk Sharp

Stennis Space Center  
Stennis Space Center, Mississippi  
39529-6000  
601/688-1929  
[kirk.sharp@ssc.nasa.gov](mailto:kirk.sharp@ssc.nasa.gov)

## NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Joseph C. Boeddeker  
**Ames Technology Commercialization Center**  
San Jose, CA  
408/557-6789

Dan Morrison  
**Mississippi Enterprise for Technology**  
Stennis Space Center, MS  
601/688-3144

Wayne P. Zeman  
**Lewis Incubator for Technology**  
Cleveland, OH  
216/586-3888

Maria Clark  
**Florida/NASA Business Incubation Center**  
Titusville, FL  
407/383-5200

## Small Business Programs

Carl Ray  
NASA Headquarters  
**Small Business Technology Transfer (SBIR/STTR)**  
202/358-4652  
[cray@hq.nasa.gov](mailto:cray@hq.nasa.gov)

Paul Mexcur  
Goddard Space Flight Center  
**Small Business Innovation Research Program (SBIR/STTR)**  
301/286-8888  
[paul.mexcur@pop700.gsfc.nasa.gov](mailto:paul.mexcur@pop700.gsfc.nasa.gov)

## NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the RTTC nearest you, call 800/642-2872.

Ken Dozier  
**Far West Technology Transfer Center**  
University of Southern California  
213/743-2353

Dr. William Gasko  
**Center for Technology Commercialization**  
Massachusetts Technology Park  
508/870-0042

J. Ronald Thornton  
**Southern Technology Applications Center**  
University of Florida  
904/462-3913

Gary F. Sera  
**Mid-Continent Technology Transfer Center**  
Texas A&M University  
409/845-8762

Lani S. Hummel  
**Mid-Atlantic Technology Applications Center**  
University of Pittsburgh  
412/383-2500

Christopher Coburn  
**Great Lakes Industrial Technology Center**  
Battelle Memorial Institute  
440/734-0094

Joseph P. Allen (Acting)  
**National Technology Transfer Center**  
Wheeling Jesuit University  
800/678-6882

Doris Rouse  
**Research Triangle Institute Technology Applications Team**  
Research Triangle Park, NC  
919/541-6980

## NASA ON-LINE

Go to **NASA's Commercial Technology Network (CTN)** on the World Wide Web at <http://nctn.hq.nasa.gov> to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

## Publications

**NASA Spinoff '97** is an annual publication that highlights products and services made possible by NASA-developed technology. Copies of *Spinoff '97* may be obtained by from the National Technology Transfer Center. & 800/678-6882. \*

## Events

NASA will present the **International Space Station's Fifth Annual Teleconference Series** via live and interactive satellite programs, providing a unique opportunity for students and professional groups to further knowledge in life sciences, biomedicine and biotechnology through an in-depth look at the benefits of research aboard the International Space Station.

On Thursday February 19, 1998, 12:30–2:00 p.m. (ET), **International Space Station: Countdown to Launch** will provide middle and high school students and teachers the opportunity to speak directly with astronauts, scientists, researchers and engineers as they discuss plans for the International Space Station.

On Thursday February 26, 1998, 1:00–3:00 p.m. (ET), **International Space Station: Open for Business** offers live and interactive dialog with world-class experts about International Space Station scientific and commercial research plans, opportunities and benefits. \*

## Multimedia

Visit the newly redesigned core web site of the online **NASA Commercial Technology Network** (NCTN) at [www.nctn.hq.nasa.gov](http://www.nctn.hq.nasa.gov) to explore NASA technologies, technology commercialization services/assistance, success stories, business resources and much more! Sign the guest book, and receive the free NCTN screen saver—now available for download to Macintosh, Windows 95/NT, Windows 3.1 and Shockwave viewing.

**Earth and Beyond: Space Technology Paves the Way** is a 12-minute video focusing on how NASA space technology is paving the way for future space missions and creating commercial products that benefit life on Earth. For a free copy, contact Michael Weingarten. & 202/358-1680, ) [mweingarten@hq.nasa.gov](mailto:mweingarten@hq.nasa.gov) \*



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